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TURBOPUMP DEVELOPMENT FOR SUSTAINABILITY

Abstract

Turbopumps play a critical role in space propulsion systems by supplying high pressure fluids to the combustion chamber instead of storing those fluids at high pressure. However, the manufacturing in the turbomachinery has shown over the years an important number of operations with a non-negligible environmental impact. Then, a comprehensive sustainability analysis is needed to have a better understanding of the root causes and a mitigation of its ecological footprints. This paper explores the different way to include sustainability in turbopump development for rocket engines, with a focus on additive manufacturing, materials selection, life cycle assessment, component optimization, and testing methodologies.

Additive manufacturing methods are scrutinized for their carbon footprint and particle/metal swarf emissions compared to traditional manufacturing techniques. Material choices and supply chain considerations are evaluated for their climate mitigation potential. Moreover, the paper investigates the sustainability impact of turbopump reusability throughout the lifecycle of space launchers, including a comparison with a single use turbopump design. The paper also quantifies on the sustainability aspects of testing turbopumps versus numerical simulation methodologies to validate designs. Lastly, the comparative sustainability of turbopumps versus e-pumps will be discussed, offering insights into future propulsion technologies.

The paper accentuates the importance of integrating sustainability principles into turbopump development. From Additive manufacturing, to material selection, through performance and assembly optimization, all contribute to the overarching goal of reducing environmental impact in rocket propulsion. Thanks to a full integrated development, rocket propulsion can further understand its environmental impact, and move towards a more environmentally conscious space exploration.